LAB: RADIOACTIVE DECAY

PURPOSE:
Investigate radioactive decay

MATERIALS:
spreadsheet, split peas, cafe cup.

https://phet.colorado.edu/en/simulation/alpha-decay

https://phet.colorado.edu/en/simulation/beta-decay

DATE_____________

AUTHOR ______________________________________

PARTNER _____________________________________

PARTNER ____________________________________

BACKGROUND:

Radioactive decay is the spontaneous disintegration of the unstable nucleus of certain atoms.

Several hundred of such unstable isotopes are known to exist naturally, and they are referred to as being radioactive. By spontaneously emitting or capturing atomic particles, the nuclei of these unstable radioactive isotopes will decay into more stable nuclei. The unstable isotope undergoing the decay is called the “parent” isotope and the resulting isotope is called the “daughter” isotope. The daughter isotope may be a stable end product or may undergo further decay and produce another “daughter” isotope.

In the continuous process of disintegration of unstable radioactive nuclei, it is impossible to predict which particular nuclei and when any one of the nuclei will disintegrate. But it is possible to predict the average rate at which nuclei will decay during a given time interval. This average decay rate is called the decay constant, and represented by 0.693/T.

The exponential decay process can be expressed mathematically by the following equation:

EQUATION (1) $N(x) = No\ e^{(-0.693x/T)}$

x is the time
Where N(x) is the number of nuclei at time x;
N_o is the original number of nuclei;
e () is a natural exponential function
T is the half life
0.693 is an approximation of ln(2)

For the purpose of this simulation, we are assuming that the decay of an unstable “parent” will produce a stable “daughter” and no other particles are emitted.

The half-life T is the time it takes for half of the parents population to decay.

Procedure

In this exercise, you will calculate the decay constant and half-life of a sample using split peas to simulate the decay of radioactive nuclei. Peas lying on their flat side will be “parents” representing nuclei not yet decayed. Peas lying on their rounded side will be “daughters” representing the decayed nuclei. Each trial represents one unit of time. **<u>We assume a time interval of 2 minutes</u>** for each trial, but since this is a simulation, we could have assumed any time interval we wanted.

1. Tape several sheets of white paper to your work table. Having this white background will make counting the peas easier.

2. Count out exactly 50 individual split peas and put them into a coffee cup.

3. Cover the cup with your hand, shake the contents for several seconds, and pour the peas from the cup onto the paper in such a way that a single layer of peas is formed.

4. Count the number of parent peas lying on their flat side, and the number of daughter peas lying on the rounded side. Record these values under Trial 1 of the Data Table.

5. Set the daughters aside. You are not using it anymore. Put the parent peas from the trial back into the cup. Shake as before and pour them back onto the paper for another trial.

6. Again, count and record both the flat lying parent peas and the rounded-edge lying daughter peas. For the parents, record only the number of peas counted. For the daughters, you should record the number counted, then add that number to the previous count so that a running **cumulative** total of daughters can also be recorded.
So if for trial 1 you get 5 daughters and 10 daughters for trial 2 you will record 5 + 10=15 for trial 2.

7. Repeat this process until no split peas are remaining.

TABLE 1 radioactive decay data

Remember in the daughters column, the numbers should go increasing.

Disregard the daughters along the trials.

trial	time(minutes(	Parent population (from 50 to 0)	Daughter population (from 0 to 50)
0	0	50	0
1	2		
2	4		
3	6		
4	8		
5	10		
6	12		
7	14	0	50

ANALYSIS

1. Use your spreadsheet. Record 3 columns :

time (in minutes) ; daughters ; parents.

2. Make a scatter plot (connect the dots) : daughters*(y-axis) vs time (x-axis).* You will staple the graph (give it a title, label the axis) to this lab report. Describe the graph below. (Is the population increasing or decreasing ? If it is increasing, what is its asymptote ?)

3. Make a scatter plot (do not connect the dots). Parents *(y-axis) vs time (x-axis).* Select the dots and select insert trend line / exponential + display equation on the graph. Staple the graph to this lab. Is the population increasing or increasing ? How do we call this decay?

4. What is the equation of this decay ?

y(x) = ________________ This is your experimental equation

The theoretical equation is :

N(x)=No e(-0.693x/T). The coefficient in front of the x is -0.693/T because -.693x/T = (-0.693/T)(x)

Compare both equation. According to your experiment No= ________

T = _________ (compare coefficients in front of x)

In theory No is 50 and T is 2 minutes. Do you get similar values ?

QUESTIONS

1) A) If an isotope has a half life of 8 days (like and isotope of iodine) and if the initial population has 100 parents, what is the equation that will describe the decay of the population ?

B) using the equation compute the number of parents left after 10 days (use your TI).

C) What is the number of daughters (so No – N(10) ?

D) open wolfram alpha and type : **plot 100*e^(-0.693*x/8) for x between 0 and 32**

What type of graph do you get ? (staple it)

According to the graph how many parents are left after 8 days ? 16 days? 24 days ? 32 days ?

Is it surprising since 8 days is the time it takes for half of the remaining parents to decay ? Explain

CONCLUSION: explain what a half-life is. What is happening to the parents and to the daughters. What type of graph do we get. What is the typical equation of a decay given No (initial parent population) and T the half life). N(x) is the population of parents at a time x. (Use another paper)